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ECONOMIC POTENTIAL OF

SOAPS, DETERGENTS, AND SURFACTANTS

MADE FROM FATS AND OILS

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PREFACE

Surfactants (surface-active agents) are marketed in many forms and in many products, but mainly as soaps and synthetic detergents. Significant quantities of animal fats and vegetable oils go into the manufacture of both soaps and detergents. About 456,000 tons (worth nearly $39 million) were used in soapmaking during 1961, and another 169,000 tons went into various detergents and other surface-active agents.

Pollution of water supplies by detergents that do not decompose rapidly in sewage disposal systems has caused a search for detergents that will decompose readily. There is interest in what the market position of fats and oils used in surfactants could be when new materials to answer this pollution problem are marketed.

This report presents results of a study of the kinds of surfactants being marketed, the role of fats and oils in their production, and the likely role of fats and oils in the products of the future.

Quantitative data in this report are from secondary sources, but the assessments of market behavior of future surfactants are based on interviews with surfactant producers, raw material suppliers, and researchers concerned with the development and use of new surfactant materials.

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SUMMARY

In 1961 the United States was using from 1,250 to 1,300 million pounds of fats and oils annually in the production of soaps, detergents, and other surfactants. In that year soap manufacturers used 912 million pounds of fats and oils, one of the lowest amounts used in any recent year. In addition to fats and oils, the manufacture of these products requires about 700 million pounds of petroleum-derived chemicals and over 300 million pounds of inorganic acids and alkalies.

Inedible tallow and grease are the chief raw materials used in the manufacture of soap and surfactants. Producers of retail syndet (synthetic detergent) formulations use annually about 66 million pounds of fat-derived nonionics of the alkanolamide type and a similar quantity of nonionic, tall oil-ethylene oxide condensates. Producers of toilet soap bars consume annually several million pounds of fatty acid-based lime soap dispersants.

About 50 percent of the surfactants produced in the United States are used in laundry detergent formulations which have a surfactant content of 20 to 25 percent. The anionic detergent formulations (ABS types) derived from petroleum dominate the household detergent market because they are cheap, stable under many conditions, and are good foamers. But for several years the use of surfactants in nondetergent applications has been growing faster than use in detergents. Cationic surfactants, for example, are not used in detergent formulations. They are used for making cleanser-sanitizers and a number of other nondetergent products.

The number of applications for fat-derived surfactants is growing and production is increasing. Fat-based surfactants have a wide range of industrial nondetergent applications. The monoglycerides and diglycerides of fats and oils, for example, are used as emulsifiers in foods, drugs, and cosmetics. About 100 million pounds of monoglycerides produced annually (much of which may be produced in situ during processing) go into foods. Fatty acid derivatives that exhibit surface activity are used in many products as emulsifiers, spreading agents, dispersants, suspending agents, antifoamers, corrosion inhibitors, solubilizing agents, deemulsifiers, and as agents that modify surface activity of other surfactants.

While no essentially new types of detergents have become major commercial successes during the past few years, consumers recently have shifted strongly to the use of liquid detergents for household cleaning. These liquid, all-purpose detergents often contain water, surfactant, and a solvent, such as deodorized kerosene. In 1961 sales of liquid syndets accounted for 21.2 percent of total syndet sales, whereas in 1956 they accounted for only 9.66 percent of total sales. The shift from solid detergent formulations to liquids took place within the existing syndet market, and had little effect on total syndet consumption or on the share of the market held by fat-based organic surfactants.

Many users of surfactants are of the opinion that straight-chain, petroleum-derived alpha olefins and the alcohols made from them will be purer, more uniform in composition, and cheaper than natural fatty acids and fatty alcohols. This is not yet true; however, large quantities of both alpha olefins and straight-chain alcohol derivatives are becoming commercially available. Tallow-derived alcohols (from fats priced as low as 4 1/2 cents per pound) are cheaper than the corresponding C_{16} - C_{18} alcohols made from petroleum. Higher priced imported coconut fats and palm oils and their alcohol derivatives are more likely to be replaced by petroleum derivatives than by alcohols derived from tallow. These imported oils provide the shorter chain (C_{12} - C_{14}) lauric and myristic fatty acids and alcohols that are needed for making

at least part of most fat-based detergent formulations. At the time of this survey, most detergent producers did not expect the petroleum-derived olefins to replace natural fatty acids and alcohols until they are cheaper or have capabilities not yet exhibited by fat- or oil-derived alcohols.

In Europe and the United States, representatives of both local and national governments are becoming increasingly concerned about water pollution from detergents that decompose slowly and affect sewage effluent treatment. Because of this pollution problem and with the increased use and availability of water softeners in homes and in central sources of water supply, individual households may begin to use more soap. However, because of the demand for detergents to do many cleaning chores in the home, the major change in cleansers will be a shift from hard to soft detergents. This shift is expected to take place in the United States by 1965. Synthetic detergents of the future are likely to be composed of ingredients similar in chemical structure to derivatives of natural fats and oils. For this reason, price rather than major technical differences will be the important factor in determining the buyer's choice of raw material.

Detergent manufacturers feel that the new detergents made from petroleum materials will cost slightly more than present detergents made of ABS materials. If these soft detergents prove to be capable cleansers, as well as highly degradable, their impact on consumer costs for cleansers should be slight. Because of the ratio of surfactant to other ingredients in a detergent, it would take an increase of 3 1/2 cents in the cost of surfactant to increase the cost of finished products by 1 cent per pound. The new soft detergents are not expected to cost the consumer this much.

The soap and detergent industries are already the lowest priced outlets for fats and oils. From the standpoint of price, the relative competitive positions of petrochemical and natural materials in the future probably will be about the same as those of materials presently used in syndets. Under these market conditions, detergent makers would not be likely to increase their use of tallow and grease derivatives. Tallow and grease derivatives will need to surpass competing materials in cleansing power or other functions to be in an improved competitive position as detergent ingredients.

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ECONOMIC POTENTIAL OF SOAPS, DETERGENTS, AND SURFACTANTS MADE FROM FATS AND OILS

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INTRODUCTION

Definitions

Synthetic detergents, originally called soap substitutes, were first introduced a little over 40 years ago. The textile industry accepted them very quickly (10), but it was not until the World War II years that the public became interested in what was by then called "soapless soaps." Although these first surface-active agents were poor general-purpose detergents, they did have the advantage of being completely active in hard water and acidulated solutions (8). The public soon recognized their usefulness, and the search for similar products with more detergent power became more active. By this time, producers had named these products "detergents." 1/

Unfortunately, many people in the surfactant industry today tend to consider nearly all surface-active agents as detergents. This tendency has led to confusion as to their differences. Actually, all organic detergents are surface-active agents, but not all surface-active agents are detergents. The terms used in this report are defined as follows:

1. The term "surfactant," a convenient contraction of "surface-active agent," includes those synthetic organic chemical products used for such purposes as wetting, emulsifying, dispersing, solubilizing, foaming, frothing, and washing or scouring (10).

2. Detergents are manmade compounds (other than soap) which are surface active in water and can be used effectively for cleaning (3).

3. The term "syndet" is a contraction for "synthetic detergent." It now connotes a detergent formulation made chiefly of synthetic materials (9).

4. "Soap" is the salt made by combining a metallic ion with a water-insoluble normal carboxylic (fatty) acid. In common usage, soap is a commercial cleansing and sudsing agent made of water-soluble salts of fatty and other natural acids. Thus, by definition, soap is differientiated from other detergents (3).

Basic Characteristics of Detergents

The two basic characteristics which distinguish detergents in solution from ordinary solutes are their ability to reduce surface tensions and to form micelles by an association-dissociation equilibrium reaction (9). Like other surfactants, a detergent consists of two parts. One part is made up of a long hydrocarbon chain

1/ Defined in the American College Dictionary, Copyright 1962, as cleansing; clearing away foul matter, as a medicinal substance; a detergent substance or agent.

that is oil-soluble and practically insoluble in water; the other part is the water-soluble portion which renders the whole molecule sufficiently water-dispersible to fulfill its intended purpose. The oil-soluble part of the molecule is usually derived from fat or petroleum; the water-soluble part may come from a number of sources. An efficient surface-active compound is obtained when the proper balance between these two groups has been established. In solution, even which in very low concentrations, these materials are able to reduce the surface tensions of their solvents and to thereby alter the surface energy of the system (11).

The ionic behavior of detergents usually determines their classification. The anionic type ionizes in aqueous solutions so that the part containing the hydrophobic or oil-soluble group bears a negative charge as, for example, sodium lauryl sulfate ($C_{12}H_{25}OSO_3^{-}\ NA^{+}$). Cationic surfactants, sometimes called "invert soaps" because they differ from ordinary soap in the sign of the electric charge carried by the long-chain ion, are typified by the quaternary ammonium salts of fatty acid amines. In the cationics, the part containing the hydrophobic group carries a positive charge. A typical ion is $-N(CH_3)_3$, the quaternary ammonium ion. In contrast to the strongly anionic (acid) or cationic (basic) detergents, the nonionic detergents and surfactants gain their hydrophilic (waterloving) characteristics from either polyhydroxylic (glycerol, sorbitol, glucoside) or polyoxyalkylene (polyglycol) side chains attached to hydrophobic molecules (fats). The amphoteric surfactants contain both acidic and basic groups in the same molecule (8, 11). They react as anionics under certain conditions, as cationics under others.

Because detergents are cleansing agents, they must possess certain capabilities. They must be able to wet the surfaces of objects to be cleaned, to emulsify, and to disperse and suspend in liquids the soil removed from objects being cleaned. Their ability to promote foaming action of their solutions is usually evidence of other powers and not a cleaning attribute in itself. (Foamless detergents often clean as well as foaming ones.)

Detergent molecules are "built" or put together so as to emphasize certain properties, such as the ability to produce foam. A detergent molecule intended to emphasize one particular property must be constructed without sacrifice of any of the other surface-active properties needed in a good detergent. Just as the number of carbon atoms in a fatty acid is of extreme importance in determining whether or not its salts exhibit soaplike properties, the number of carbon atoms, their structural configurations, and the location of the active ionizing groups are of importance in determining the properties of molecules in the newer synthetic detergents.

In many washing operations, the detergent must be combined with inorganic salts (called builders or additives) to boost cleansing action. For example, caustic soda added to detergent makes an excellent cleaner for glassware; sodium metasilicate and trisodium phosphate combined with detergent are very effective cleaners for ceramic surfaces; and sodium pyrophosphate and detergent make a good cleaner for metals. Molecular structure is very important when a molecule is being prepared to perform special tasks. But this functional design in the molecules of surfactant compounds is somewhat obscured by the fact that most of the large-volume commercial products are mixtures of surfactants and additives or builders. In most commercial detergents, the chief ingredients for volume and cleaning action are the inorganic salts. The ability of these salts to saponify fatty or oily dirt with the formation of some soap *in situ* helps the cleansing action of the surface-active agent.

The first "built" synthetic compositions to be commercially introduced were high-foaming products that foamed as well in hard water as soap did in soft water.

However, the additional foam became a nuisance. Heavy foam often smothered the mechanical action of washing machines and overflowed. Low-foaming formulations, such as tallow alcohol sulfates combined with petroleum-derived synthetics, were then developed and promoted with remarkable success. 2/ Because of the large number of variations in detergents and surfactants and the many different forms in which they are marketed, the market picture for these products is confusing. They appear as liquids of various concentrations, as powders and pastes, as waxy solids, and as combinations of various ingredients.

Soap is undoubtedly the best known and oldest of the manmade detergents, although it is not classed as a synthetic detergent. Most synthetic detergents contain a sulfate or sulfonate at the ionizing group instead of the metallic ion carboxylate group found in soap. But like soap, these sulfates and sulfonates are anionics. 3/

Retail detergents, and particularly household laundering compositions, are normally fairly complex compositions or mixtures. The so-called heavy-duty detergents, which account for the biggest part of sales in the household detergent market, consist of an anionic synthetic surfactant mixed with inorganic salts, an anti-redeposition agent, such as carboxymethyl cellulose, a fluorescent brightener, a foam stabilizer, and a perfume. The surface-active agent content may range from as low as 15 percent (typical of low-sudsing commercial syndets) to as high as 35 to 40 percent of the total composition. The inorganic salt content is as much as 65 percent or more of the total weight of the product.

Some producers use more than one surfactant in their retail products. For instance, dodecylbenzene sulfonate, used to promote rapid-forming, voluminous foam, is mixed with a tallow alcohol sulfate to obtain smaller bubbles and greater foam stability. Detergents containing both dodecylbenzene sulfate and tallow alcohol sulfate leave fabrics with a softer feel after washing than ones containing only dodecylbenzene sulfates.

The surfactant compounds that go into household and industrial detergents are chosen on the basis of performance and cost. How well a detergent performs depends on the composite effect of its physical properties. A detergent is not acceptable if greatly deficient in any requirement. A deficiency in one kind of surfactant is often offset by the addition of other ingredients. For example, the inability of synthetic detergents to produce a lather, and at the same time give the familiar feel of a toilet soap, is one of the reasons why syndets have not been able to move into this market. The addition of a fat-based cold cream to the syndet bar is one way of trying to overcome this deficiency.

The growth of liquid detergents has been phenomenal. They were first introduced for use in home dishwashers. The nonionic forms first used could not compete with

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2/ This need for low-foam detergents also led to the widespread use of the nonionic detergents typified by the tall oil-ethylene oxide condensate types. The low-foaming nonylphenol and isooctyl phenol-ethylene oxide condensates, originally developed as textile scouring agents for use on raw wool, feathers, or cottons, were first used in low-foaming liquid detergents.

3/ Some typical representatives are sodium lauryl sulfate, sodium dodecylbenzene sulfonate, sodium N-methyl-N-oleyltauride, and sodium nonylphenoxy polyethoxyethyl sulfate. Among nonionic detergents, typical formulations include the polyethoxyethyl tall oil esters, nonylphenoxy polyethoxyethanols, and some alkanolamides.

the sulfonated and sulfated anionic types in producing foam. 4/ Heavy-duty and light-duty liquid detergents are now major commercial items. 5/

Today syndets account for about half of the U.S. production of synthetic surfactants. Nearly every industry uses surfactants to some extent when it is desirable to bring surfaces closer together quickly. The technological factors involved in the expanded use of syndets and the concomitant decline in the use of fats and oils were analyzed in a 1953 report published by the U.S. Department of Agriculture (7). Additional factors which have more recently become apparent are discussed in this report.

Basic Characteristics of Emulsifiers and Other Surfactants

A marketing research report published by the U.S. Department of Agriculture in 1953 (7) states that in 1952 the United States was consuming about 360 million pounds of emulsifiers per year and that in 1953 nearly 100 producers of emulsifiers manufactured 600 products. In 1961 the number of producers was about the same as in 1953, but the total volume consumed was about 50 percent higher (over 500 million pounds).

Most emulsifiers are produced in much the same way as the detergents previously described. Ordinarily, emulsifiers should be soluble or dispersible in the oils or solvents they emulsify and capable of lowering the interfacial tension between oils or solvents and water. Certain oils require specific emulsifiers to produce emulsions for special uses.

In addition to their use as emulsifiers and detergents, surfactants have many other applications, especially in industrial operations. In fact, during most of the 1930's, the term "wetting agent" was used to describe most of the new surface-active agents that were being introduced.

Surfactants are used for many purposes. Some are used as wetting agents, as solvents (called solubilizers), as dispersants (chemicals called polyelectrolytes), as antifoaming agents, and foam stabilizers. Millions of pounds of surfactants are consumed annually for use as deemulsifying agents for crude petroleum oils, as corrosion inhibitors, as base ingredients in rust-preventive oils, and in various petroleum refinery operations. As dispersants they are used as stabilizing and viscosity control agents, as stabilizers for certain types of soil and soil-aggregates used for highway construction purposes, and in oil-well drilling muds.

Both cleaning power and wetting action are often highly specific characteristics of surfactants, depending not only on which surfactant is used but also on the kind of material to be cleaned or wet. It is often desirable to promote wetting without increasing the detergent or emulsifying action. Surfactants are widely used as textile wetting agents, as agents to speed the wetting of surfaces by paint films, insecticidal dusts, adhesives, and powdered solids. Thus, wetting agents may be aqueous or nonaqueous.

4/ Tall oil-polyglycol esters were unable to compete with the alkylphenol polyglycol ethers, despite good detergent action and low price, because the ethers are more stable in acids or alkalies; whereas the esters are saponified or hydrolyzed in these solutions.

5/ Compounds such as the dodecylbenzene sulfonates, sulfated polyoxyethylated alkylphenols, and foam stabilizers of the alkanolamide type.

Latex paint makers and many industries, including the textile, paper, cosmetics, and metalworking industries, require surfactants for purposes other than cleaning. The technical basis on which surfactants are chosen for such applications include, among others, selective material-wetting ability, necessary in ore flotation operations or in textile softening; emulsifying ability; and the ability to produce foam. Surfactants capable of producing foam are needed in making air-entrained concrete. In all these instances, surfaces of materials are brought closer together more rapidly than they are when a surfactant is present.

FACTORS AFFECTING THE SELECTION OF RAW MATERIALS FOR DETERGENTS AND OTHER SURFACTANTS

Materials Used as Soap Substitutes

Synthetic detergents, originally known as soap substitutes, were developed in Germany during World War I when the Allied blockade shut off access to imported fats and oils. The first commercially successful petrochemical product, alkylnaphthalene sulfonate, was synthesized from raw materials derived from coal tar, found in abundance in Germany. 6/ It was the forerunner of the vast array of surfactants now on the market. Its commercialization practically coincided with the start in 1925 of the American Petroleum Institute's program of fundamental research on the origin, recovery, production, composition, and properties of petroleum.

The alkylnaphthalene sulfonates derived from coal tar were welcomed by the textile industry, but they lacked the detergent abilities the general public wanted. So, the first really effective synthetic detergents were actually derived from fat. The "Igepons" were made with a fatty acid in which the carboxyl group was blocked by the addition of a short hydrocarbon chain with a reactive group at the end. 7/ The "Igepon T" surfactant is still used today in textile processing and other operations. Its sales are increasing once more because of its capability as a lime soap dispersant, the material needed to make regular toilet bar soaps satisfactory for use in hard water. As the Igepons and Nekals (6) were being developed, chemists were exploring other means of taking advantage of the known hydrophilic-hydrophobic characteristics of fatty acid derivatives. This effort led to the production first of fatty alcohols and then of fatty alcohol sulfates. Then, in the early 1930's U.S. chemists chlorinated a narrow kerosene cut and alkylated benzene with it to produce a satisfactory nonfat hydrophobic raw material from petroleum. This was sulfonated to produce the first of the modern alkylbenzene sulfonates (11).

Oils and Fats

Practically all of the natural oils and fats of trade except tung oil and butter have been used in the commercial production of soaps. Only a few are used today in synthetic detergents, sulfated oils, emulsifiers, textile softeners, soaps, and other types of surfactants. Polyunsaturated fats and oils turn rancid, darken in color, and can change characteristics when acted upon by oxygen or enzymes. Surfactant producers have found that oils and fats with a high proportion of saturated fatty acids

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6/ Ger. Pat. 336,558, to Badische Anilin- & Soda-Fabrik.

7/ "Igepon," "Igepon T," and "Nekal" are registered trade names of the General Aniline and Film Corporation.

and fatty acid chains of 12 to 18 carbons make the most suitable soaps and detergents. Tallow, grease, palm oil, and vegetable oil refining residuals (foots) meet these requirements best.

Surfactant makers prefer raw materials that are stable in price, quality, and supply. They like to manufacture products that can meet rigid specifications on properties and chemical structure. This enables them to quote firm prices on long-term contracts and to guarantee that their products meet certain standards of performance. Fats and oils have had disadvantages in one or more of these market conditions, when compared with competing materials. These disadvantages have caused fats and oils to lose a part of their share in some major volume markets. On the other hand, fats and oils are more versatile than petroleum raw materials. This versatility of fats opens new doors of market opportunity in new surfactants.

Petrochemicals

Detergent and surfactant producers started using materials derived from petroleum when the petrochemical industry began. The kerylbenzene sulfonates were early commercial detergents derived from petroleum. These sulfonates were made from a carefully selected petroleum-cracking fraction in the kerosene cut range. This alkyl fraction (keryl kerosene), condensed with benzene in a Friedel-Crafts reaction and sulfonated, was the major synthetic surfactant in the American synthetic detergent market during the late 1930's and most of the 1940's. It and later types were replaced by the modern-day dodecylbenzene or tridecylbenzene sulfonates, commonly called ABS, in which the alkyl chain is a tetra-propylene or tri-isobutylene structure. The term "ABS" is a generic term and not a specific chemical formula.

The commercial starting materials for these ABS alkyls are short (3 or 4 carbon atom) aliphatic hydrocarbons, such as propylene and isobutylene, which, when converted to small polymers (mostly trimers and tetramers), are used to alkylate the benzene. The alkylbenzene sulfonates with their important carbon-to-sulfur bond structure are not only good detergents with excellent foaming properties but are also stable in the presence of both strong acids and alkalies. According to R. D. Swisher, the alkyl group, ranging from 12 to 15 carbons, appears in as many as 80,000 combinations. 8/

As nonionic detergents and sulfated derivatives of alkylphenols, the alkylphenol-ethylene oxide condensates (for example, nonyl phenoxy polyethoxyethanols) are currently the strongest competitors of the alkylaryl sulfonates (mostly ABS) in both retail and industrial detergents. Phenol, derived from coal or petroleum, is alkylated with such small polymers as di-isobutylene or tripropylene. The alkylphenol formed is then condensed with ethylene oxide to form a nonionic surfactant. If it is sulfated, it becomes a high-foaming detergent of the anionic type. Among nonionics, the polyoxyethylated alkylphenols are better hard-surface cleaners, emulsifiers, and lime soap dispersants but poorer foamers than most alkylarylsulfonates. Alkylphenol makers said that they have a bigger share of the nondetergent market than the makers of ABS type detergents. As nondetergents, alkylphenols have strong competition from a wide variety of more expensive products, both fat- and petroleum-derived, with properties of high value in specialized industrial applications.

Oxo-alcohols, also derived from petroleum, are branched carbon-chain products possessing an -OH group somewhere in their molecular structure. They can be

8/ Swisher, R. D. Relations between Structure and Biodegradation of Surfactants. Speech before the Soap and Detergent Assoc. (New York) Jan. 24, 1963.

sulfated to make products that can compete with the sulfated straight-chain fatty alcohols as ingredients of detergents. Oxo-alcohols can also be condensed with ethylene oxide to give ether type surfactants that compete with the nonionic fatty alcohol and alkylphenol ethers. Their ethers can also be sulfated to produce high-foaming detergents. In surfactant properties, the tridecyl alcohol derivatives are most similar to alkylphenols and derivatives of lauryl and longer chain fatty alcohols. However, surfactant makers who have been using straight-chain fatty alcohols and their derivatives for years claim they will not shift to Oxo-alcohol products unless they become cheaper. Those that have already adopted or changed to alkylphenol derivatives stated that they do not feel the Oxo-alcohol derivatives will ever be as cheap as the alkylphenol types, and that they would consider changing only if these derivatives exhibit some unexpected or special property that the others lack. At the time of these interviews, biodegradability was not considered. Should biodegradability become a requirement, Oxo-alcohols would be in an even weaker competitive position.

Miscellaneous Raw Materials

According to Ayo, Bruun, and Matchett (1), lignin, a major polymeric component of wood tissue, ranks second to dodecylbenzene in poundage used in synthetic surfactant production. Because it is made up of repeating phenyl propane units (3), lignin is a surfactant raw material from wood that is often credited to petroleum sources.

In additon to surfactants derived from lignin, a number of synthetic surfactants, including some used in formulating large-volume detergent compositions, contain both fatty materials and petroleum-derived chemicals. Others are combinations of organic and inorganic materials, such as phosphate fatty esters, sugar esters, and cellulose derivatives. Some of these are used as detergents, foam stabilizers, emulsifiers, and corrosion inhibitors; others are used for a number of other purposes.

BIODEGRADABILITY FACTORS

With an increase in the use of detergents, the problems of biological degradability of sewage wastes and of biological oxygen demand (BOD) in sewage effluent disposal have become more important. Makers of detergent raw materials are diligently seeking a solution to the problem of making biologically soft detergents. A great deal of effort has gone into research and experimental work to measure the relative biological oxidative stability of various straight-chain and branched-chain surfactants in sewage. By 1965, detergent manufacturers expect to offer products that will meet the needs for soft syndets. They do not expect these new syndets to solve other water pollution problems noted later in this report.

It is difficult to predict how much the eventual cost of new biodegradable detergents to consumers may be. A cost change for about 1 billion pounds of surfactants now used by consumers would be involved. It takes an increase of 3 1/2 cents per pound in surfactant cost to the detergent maker to cause an increase of 1 cent per pound in the cost of the typical household detergents. Each 1 cent increase in cost to detergent consumers would total about $35 million annually. Indications are that surfactant producers and detergent makers will absorb small cost increases for the soft detergents and consumer costs will not rise.

Many of the problems of water pollution from sewage disposal will not be solved even if a change to biodegradable detergents occurs. The foam that appears in streams and polluted underground waters is in many ways only an indication of a much larger problem. Chemical analysis of foamy water often reveals that other organic and inorganic waste materials are present. These latter materials are often found in much larger concentrations than the foam-producing detergents.

Population increase and urban expansion place a burden on nature as a water purifier. As the population of a city grows, the intake of water from natural surface and underground sources increases. This increased intake is put back into the fresh water stream as sewage effluent, which becomes the bigger part of the total stream flow beyond the point of discharge. As the amount of fresh water that can be used to dilute sewage effluent becomes smaller, nature's ability to oxidize wastes in the stream bed becomes overtaxed. Subsurface waters that receive effluent from septic fields also become overloaded in a similar manner.

Today, the problem of sewage effluent conditioning is becoming more and more important. The elimination of foam may require a change in detergent composition. As important as the problem is, the question of what to do about water pollution caused by the presence of other more toxic waste materials in water is of even greater importance. To assess and establish methods for control is particularly difficult since the actual conditions of sewage disposal are more complex than the laboratory conditions that have been set up to evaluate biologically soft detergents (4).

One of the dangers believed to be inherent in the continued use of nonbiodegradable detergents is that they could be the means by which sewage-born bacteria and viruses are carried into wells and other fresh water sources. A change to biologically soft detergents that will degrade in the sewage treatment plant or septic tank will reduce this danger.

A change of the chemical structure of syndets is not the only way to relieve the sewage effluent problem. Another way is to reduce wasteloads. Treatment plants could then serve the population more efficiently. Increased use of home garbage disposers, inefficient recovery of solids from industrial waste water, and the use of water to remove wastes that could be handled in dry or solid forms all place an extra burden on sewage treatment plants and increase the wasteload put on the natural water resources of an area. A third way to remove foamy suds from sewage effluent is to use soap and water softeners or lime soap dispersants instead of detergents. Many commercial laundries have continued to use soap, and to add water softeners when necessary, instead of changing to detergents. Laundry operators say that very hot water, soap, an alkali, and water softeners (when needed) clean clothes more satisfactorily than detergents and do not harshen fabrics as much.

In commercial laundries 1 pound of laundry soap made from tallow and 1 pound of alkali can clean 200 to 300 pounds of soiled linen. The soap initiates sudsing action and the hot water helps the alkali to form more soap by saponification of oils in soil removed from laundered materials. Under the most favorable conditions, 1 pound of soap and 1 pound of alkali produce as much cleansing action as 4 pounds of synthetic surfactant. The difference in cost is significant. Soap and alkali cost the laundry less than 1 cent for each 10 pounds of soiled linen. A syndet of equivalent sudsing and cleaning power would cost a laundry 10 times as much.

The hardness of water should be the deciding factor in the selection of a cleansing agent (detergent or soap) for use in home laundering. In many areas of the United States, water supplies do not contain enough calcium or magnesium salts to warrant the use of synthetic detergents. In these areas, soap with a small amount of lime soap dispersant or water softener can clean soiled linens as well as a detergent. Commerical laundry operators are expected to continue to use soap because it is cheaper and leaves fabrics softer than detergents.

Much attention has been given to the possibility of substituting a straight-chain alkyl group for the branched-chain alkyl group now used in making alkylbenzene and alkylphenol raw materials. It is debatable whether the substitution devised will be an adequate solution. There are still questions as to their detersive qualities and their rate of biodegradability in present sewage treatment and disposal systems, particularly under anaerobic (home septic tank) conditions. There straight-chain materials and many other synthetic surfactants, which may be used as detergent ingredients or as emulsifiers in products going into sewage eventually, are more resistant to chemical action and to biological activity than soaps. Two questions that have been raised about detergents of the new soft ABS type are (1) whether the straight-chain alkyl group will be biologically degraded readily enough and (2) what happens to the surfactant molecule remnant, the sodium benzene sulfonate.

The methylene blue test, the standard test now used for assessment of degradable organic materials in river or sewage effluent water, measures the amount of oxidizable material in water. It is not a satisfactory measure of aromatic (benzene, phenol, or other carbon ring compounds) materials that may remain in effluent after the alkyl chain has been degraded. Thus, this test may indicate virtually a zero concentration of biodegradable material, yet the water may contain benzene sulfonate remnants in high concentration without the alkyl chain needed for high detergency. These benzene sulfonates are not desirable materials in water to be used for crop irrigation or for drinking. These materials eventually degrade too, but in rivers and underground waters they can survive for days, and thus could become a part of fresh water used at another location.

TRENDS IN THE DETERGENT MARKET

Trends in Research and Product Development

For the past 40 years, research in the detergent industry has stressed the production of synthetic products that will be better than soap for tough cleaning jobs and yet competitive in the commercial market. In the process, new uses for surface-active materials were found. These discoveries led to the manufacture of an ever-increasing number of chemical compositions for use in surfactants. Of the thousands produced commercially, less than a dozen types are marketed in large volumes. Many producers manufacture several of these smaller volume items, as well as other speciality surfactants for small markets, with more profitable price margins than the ABS types offer to producers.

The research interests of the suppliers, producers, and marketers of detergent raw materials have recently changed. Product research is now directed toward finding raw materials and finished product compositions that will meet biodegradability requirements. Properties, as well as cost, have become the guides in detergent research.

Production and Sales Trends

The industrial surfactant market is growing faster than the retail detergent market. The use of retail detergents increases in proportion to population increase, but increase in the use of industrial surfactants is not related to the population factor. Since practically all industries are finding some use for surfactants, the number of industrial surfactants, as well as the number of applications for them, has grown and continues to grow rapidly.

The production of surfactants in the United States is shown below:

Year	Cyclic compounds		Acyclic compounds	Total of all types
	ABS	Other		
	Thousand pounds	Thousand pounds	Thousand pounds	Thousand pounds
1946.......	45,868	49,505	147,001	242,374
1948.......	101,443	74,786	198,486	374,715
1950.......	261,931	121,343	293,072	676,346
1952.......	307,242	170,401	263,504	741,147
1954.......	388,959	251,263	385,614	1,025,836
1956.......	462,051	289,563	396,392	1,148,006
1958.......	509,033	337,289	508,752	1,355,074
1960.......	542,381	434,816	555,030	1,532,227

Source: U.S. Tariff Commission

These data show that the alkylbenzene sulfonate surfactants (ABS type, exclusive of soaps) increased from 19 percent of the total surfactant market in 1946 to 40.6 percent in 1952. Though this percentage dropped to 35.3 by 1960, the annual production of the ABS-type surfactant has shown gains in tonnage every year since the end of World War II. Analyses of data on other major types allow several general inferences about trends: (1) The nonionic types have been increasing both in tonnage produced and in their share of the market during this period; (2) The volume of cationic surfactants and surfactants containing nitrogen has been increasing in recent years; (3) Miscellaneous sulfated and sulfonated oils and fats and soaps have been decreasing in relative market volume; and (4) The fatty alcohol sulfates, the chief prewar surfactants, have lost some of their market stature statistically, while ethylene oxide condensate types have shown rapid growth.

Sales of soap and synthetic detergents from 1948-61 are shown below:

Year	Hard soap	Syndets	Totals	Syndets as percentage of total
	Million pounds	Million pounds	Million pounds	Percent
1948.......	2,491.4	401.7	2,893.1	13.9
1952.......	1,824.2	1,530.1	3,354.3	45.6
1956.......	1/	2,690.3	1/	67.0
1960.......	1,056.9	3,310.6	4,367.5	75.8
1961.......	1,014.5	3,469.1	4,483.6	77.5

1/ Basis of estimating changed in the May 1958 release of 1909-57 sales data.
Source: Soap and Detergent Association

All soap and syndet volumes in the above tabulation are based on the weight of the finished product. Data from the Soap and Detergent Association, based on an industrial consensus, sales census reports, and data from Census of Manufactures, are compiled regularly from current collections. The data from the Soap and Detergent Association exclude many surfactants not used in synthetic detergents and include materials that are combined with surfactants to make a complete product. The Tariff Commission data, on the other hand, include only the surfactants.

Except for scouring cleansers, most syndets contain 15 to 40 percent organic surfactant (9). The solid, light-duty syndets consist mainly of active surfactant agents (9) and a neutral builder or extender in a 1:2 ratio. Heavy-duty syndets are more complex in makeup, and the surfactant constituent usually accounts for 20 to 30 percent of the total composition. The consensus of persons engaged in detergent market research is that active surfactant agents account for an average of 25 percent of the total syndet volume. 9/

On the basis of this average and the sales figures of the Soap and Detergent Association, all syndets made in 1948 could have been of the ABS type, but the 1961 volume of ABS was 300 million pounds less than that needed to make all syndets. Thus, it can be said that, although the volume of surfactants is increasing greatly, the share of the market held by surfactants of the ABS type has declined sharply.

An estimated 85 percent of the alkylbenzene sulfonate production goes into solid, heavy-duty syndets. Most of the 150 million pounds of fatty alcohols estimated to be produced each year go into the making of toilet articles, such as hair shampoos, and into syndets used for laundry purposes. Alkylbenzene sulfonate and fatty alcohol production volumes of the size estimated cannot fulfill the needs of syndet makers today, though such volumes would have been more than adequate 15 years ago.

Trends in Product Forms

A strong trend toward the use of liquid syndets has already been noted. Light-duty syndets account for 97 percent of the liquid detergent market, but only 5 percent of the solid syndet market. Detergent tradesmen interviewed during this survey felt that heavy-duty liquids will replace more and more of the light-duty liquids now in use. Most felt that solid syndets would maintain their present volume in the market despite the percentage gains of liquids.

Sales of liquid syndets as a percentage of the total U.S. syndet market are shown below:

Year	Total syndets	Solid syndets	Liquid syndets	Liquid syndets as percentage of total
	Million pounds	Million pounds	Million pounds	Percent
1956	2,690	2,430.6	259.7	9.66
1957	2,896	2,532.3	363.5	12.50
1958	2,951	2,520.6	430.7	17.10
1959	3,204	2,637.3	566.2	17.70
1960	3,311	2,665.4	645.3	19.50
1961	3,469	2,735.0	734.0	21.20

Source: Soap and Detergent Association.

9/ An active surfactant agent is an organic detergent with a suds booster. Liquid syndets contain a hydrotrope as well.

These data from the Soap and Detergent Association show the syndet sales trends in recent years. Solid syndet sales gained 1.1 to 2.9 percent a year in most of these years; liquid syndet sales in both 1960 and 1961 increased 14 percent a year.

Toilet soap bars containing syndets now account for about 20 percent of the total toilet soap bar market. This is a decline from a market share of almost 25 percent several years ago when some new syndet bars were strongly promoted. Toilet soap bar sales have shown a steady growth since 1950, with 1960 sales of 577.6 million pounds (54.7 percent of the total soap market). This is in sharp contrast to laundry bar soaps which had had sales of more than a billion pounds a year before 1942. These laundry soaps had about one-third the sales volume of toilet bar soaps in 1961.

Syndets have penetrated the laundry bar soap market far more than initial estimates made of their market potential indicated. The big shift from soaps to syndets was due largely to the intrinsic values of synethetic detergents to housewives in soft-water areas. Although there has been no evidence that housewives would begin using laundry soap again, publicity on foam and pollution may cause some people to consider discontinuing the use of detergents.

Trends in Specialty Detergents

Specialty detergents include household scouring cleansers, solvent syndets, a wide variety of industrial cleaning formulations, and detergents used in commercial laundries (mostly self-service), in textile processing plants, and for metal and other hard-surface cleaning jobs. In syndets used for these purposes, wetting action, emulsifying ability, and other properties peculiar to surfactants are usually more important than the broad spectrum of properties needed in household syndets.

According to the Soap and Detergent Association, which reports sales of scouring cleanser separately from soap and syndet sales, retailers sold 367 million pounds of scouring cleanser in 1959, 375 million pounds in 1960, and 414 million pounds in 1961. These cleansers contain only about 3 to 4 percent of the type of surfactant used in detergents. According to a recent report of the Chemical Specialties Manufacturer's Association, most of the industrial cleaning compounds, with an annual sales volume just below 200 million pounds in 1961, need small amounts of organic surfactants. Though sales of these specialties are steadily increasing, this sales increase has very little effect on the surfactant market volume. An annual increase of a few million pounds of total product, containing less than 5 percent of organic surfactants, amounts to only a few hundred thousand pounds of surfactants.

The new liquid, all-purpose detergents have had the most phenomenal growth of any single type of detergent on the market. Their annual sales volume increased from 35 million pounds in 1958 to approximately 170 million pounds in 1960. These detergents are used to clean the hard surfaces in homes, such as walls, appliance surfaces, and table tops for which housewives have no mechanical aids. All-purpose liquid detergents usually contain an organic solvent (preferably odorless and nonflammable), water, and a surfactant.

The development of detergents for use on hard surfaces was stimulated largely by the needs of the textile processing industry. This industry uses detergents such as these to scour wool and rayons. It also finds them useful for dyeing operations and the after-wash of colorfast prints. When used for these purposes, hard-surface cleaning formulations consist, for the most part, of inorganic salts and alkalies or acids, and are therefore materials other than surfactants. These inorganic materials are cheaper than most organic surfactants. The amount of organic surfactant needed in their formulations is usually very low. The number of uses and outlets for these detergents continues to grow as methods for performing cleaning jobs improve. Because of the textile industry's success with these detergents, several other industries (dairy, railroad, automobile, aviation), food-packing establishments, and other businesses have begun to develop uses for them.

More market growth is expected for household products of this type too, particularly those used for washing surfaces that are not readily wet by water or by aqueous solutions of highly water-soluble detergents. Some fabrics, for example, contain synthetic fibers with hydrophobic hard surfaces which tend to get grayer and darker with repeated washings. The soil that clings to these fibers is not readily removed by soap or normally used household syndets, but it is easily removed with the newer all-purpose liquids.

Trends in the Use of Surfactants

According to participants in the American Chemical Society Symposium in Cleveland in April 1960, the industrial market for synethetic, organic surface-active agents, on a 100 percent active basis, is becoming larger than the household market for surfactants. 10/ This means that the 60:40 tonnage ratio between surfactants used in households and those used in industrial operations changed during the late 1950's to at least a 50:50 ratio, despite the sales gain for household syndets. This adds market significance to a statement given earlier in this report that surfactants are valuable whenever it is desirable to bring surfaces closer together. It also lends market significance to the consideration of the use of fats and oils in the section "Emulsifiers and Other Surfactants."

A complete listing of industrial applications for surfactants is actually impossible because new uses are being uncovered almost daily. A partial listing, mostly by categories, follows (9):

1. Textile auxiliaries: Dyeing assistants; wetting agents; emulsifying, lubricating, and sizing agents; and antistatic agents.

2. Medicinal and cosmetic applications: Emulsifiers for ointments and creams, shampoo bases, specialty skin cleansers, bath preparations, shaving creams, and dentifrices.

3. Metal and mineral processing assistants: Cutting and fabricating lubricants, electroplating and surface-finishing assistants, ore flotation and benefication assistants.

4. Building and construction industries: Antistripping agents and emulsifiers for asphalt, portland cement, and concrete additives; and soil stabilization aids.

5. Agricultural and food uses: Fertilizers and soil conditioners, pesticidal emulsifiers, wetters and dispersants, emulsifiers and solubilizers for a wide variety of food products.

10/ Expressed in terms of surfactant consumption, excluding materials that may be used with surfactants in proprietary product formulations.

6. Leather, fur, paper, and plastic processing aids: Emulsifiers, fat-liquoring agents, wetting and rewetting agents, antistatic agents.

7. Synthetic polymers, rubbers, and paints: Emulsifiers and suspension aids for paints, for polymerizations, for stabilizing and creaming of latexes, and for gelling, grinding, and dispersing of rubbers, paint ingredients, and urethane foam polymers.

8. Petroleum and chemical processing assistants: Aids in primary and secondary recovery operations, demulsifiers for crude petroleum, corrosion inhibitors, antioxidants for fuel oils, and chemical reaction accelerators.

9. Miscellaneous: Foaming and foam-prevention agents, firefighting aids, deicing compounds, wax polish and hydraulic fluid ingredients, spreading and emulsion agents in inks, germicides, embalming fluids, and mothproofing compositions.

Statistics are not available on the quantity of surfactants used in each of these categories, but about three-fourths of a billion pounds are consumed annually for use in all categories. The alkylbenzene sulfonates and fatty alcohol sulfates may have an overwhelming share of the household syndet market, but they account for only a part of the industrial business. During this survey detergent makers and persons engaged in detergent research often pointed out that no product offers the maximum in all performance characteristics of surfactants, such as wetting, emulsifying, dispersing, solubilizing, and detergent action. Some surfactants are better than others in a given application. A surfactant product that is otherwise highly satisfactory may be limited in use if it is toxic, if it irritates the skin, or if it will not emulsify without producing foam.

In new surfactants developed for nondetergent uses, performance is more important than price. New surfactants are gaining markets as nondetergents, very often replacing alkylaryl sulfonates and fatty alcohol sulfates formerly used for want of materials with more specific surfactant capability. Surfactants that are combinations of agricultural- and petroleum-source raw materials are being used increasingly as nondetergents. Statistics from the U.S. Tariff Commission reports, for example, show the ethylene and propylene oxide condensates, the polyglycol esters and others, and the acyclic, nonsulfonated surfactants containing nitrogen as those materials in this classification that are growing rapidly in volume.

The nondetergent surfactants mentioned appear to be increasing in volume collectively at a more rapid rate than syndets used for household and commercial purposes. This is due to a high degree of saturation of the market potential of household cleaners and to the ever-increasing number of new surfactant applications. For example, fat-based surfactants are now used to destroy unwanted foam that occurs during the boiling of maple sap. A surfactant that destroys unwanted foam during boiling down of maple sap to sirup and sugar is just one example of such a new use for fat-based surfactants.

Trends in the Use of Fats and Oils in Surfactants

Surfactant makers are using larger quantities of fats and oils in the manufacture of their products. This is contrary to the popular belief, found even within the surfactant industry, that petroleum chemicals dominate and will continue to dominate this market. Errors in the assessment of market volume for fats and oils are often caused by overgeneralization as to the classification of materials. Contrary to such classifications, many synthetic detergents and other synthetic surfactant materials are made from fats and oils and their derivatives.

All emulsifiers used in food products, cosmetics, and medicines are surfactants derived primarily from fat. Solubilizing agents, dispersants, shampoos, and foaming and defoaming agents also contain fat-based surfactants. The quantity of these surfactants and emulsifiers consumed annually now exceeds 100 million pounds and is continuing to increase. According to industry sources, fat-based materials will continue to be some of the principal ingredients of foods, cosmetics, and medicines. Cost and other requirements for Food and Drug Administration approval of new products with these applications are major reasons surfactant producers expect to continue using fat-based materials in their products.

Greater use is also being made of fat-based, surface-active germicides in germicidal detergents, sometimes called detergent-sanitizers. Fat-based cationic softeners are combined with starch to make new fabric softeners. These softeners are used in the final rinse of the washing cycle in which a detergent has been used. Fabric softness, lost by the use of detergent, is restored by the addition of a newly developed fat-based product.

The quantity of surfactants used in individual specialty products is not outstanding when compared with the volume of ABS used in general-purpose syndets. However, Ayo, Bruun, and Matchett (1) show that from 350 to 400 million pounds of fat-based chemicals are used in surfactants. This volume includes fatty materials used for making detergents but not soaps. Also, it does not include about 156 million pounds of lignin from the wood pulp industry and smaller amounts of other raw materials, such as rosin amines, sugar esters, and starches and gums from natural sources. The total volume of natural fat-derived surfactants consumed annually is only 30 million pounds less than the 700 millior pounds of petroleum-based surfactants consumed. The success of smaller firms in developing specialty products from fats and oils for the surfactant market provides an additional reason for giving attention to these natural materials and their versatility in specialty surfactant products.

Fatty Alcohols versus Alpha Olefins

The straight-chain alpha olefins and alcohols from petroleum, which were recently made available, are a potential threat to natural fatty alcohols used in detergents, and consequently to fats, oils, or fatty acids from which they are derived. These straight-chain olefins are made by the polymerization of ethylene to longer chain alpha olefins or by the "cracked wax" process, a splitting of petroleum waxes to yield C_6 - C_{20} straight-chain alpha olefin molecules which are converted to alcohols. 11/ The offering price for these materials will be a key factor in determining how well they will compete with the alcohol derivatives of natural fats and oils. Many prospective users say that the petroleum-derived, straight-chain alcohols will displace fatty alcohols to a large degree only if they are cheaper than the natural alcohols. They also feel that these straight-chain, petroleum-derived alcohols can be offered as purer, more uniform, and cheaper chemical processing intermediates than natural fatty alcohols. This has not been true of products offered heretofore.

11/ Hinds, George and Miller, E. S. Sources of Straight-Chain Alpha Olefins. Paper presented at the annual convention of the Amer. Assoc. of Soap and Glycerine Producers (now Soap and Detergent Assoc.) N. Y., Jan. 25, 1962. (Abstracted in Oil, Paint & Drug Rptr., Jan. 29, 1962).

Consumers of natural fatty alcohol believe that tallow alcohol, generally offered at about 20 cents per pound, could be made available in large quantities at a cost of between 11 and 14 cents per pound.

Price competition between petroleum-derived alcohols and the fatty alcohols from imported coconut fats and palm oils is not as clear-cut as it is between those derived from tallow and grease and those from petroleum. Alcohols derived from coconut and palm oil are nominally priced above 30 cents per pound. They have more desirable carbon chain lengths for good detergency (C_{12} - C_{14}) than the tallow alcohols (C_{16} - C_{18}). A large part of the total market for coconut and palm oils is as a captive material for the major soap and detergent producers from the point of production to the wholesale or retail distributor. In a marketing situation of this kind, it is almost impossible to predict the price at which petroleum-derived fatty alcohols must be sold to replace coconut or palm oil products. Detergent makers who do not produce natural fatty alcohols will be the first market for the new alpha olefins and synthetic fatty alcohols from petroleum. These producers supply only a small part of the total market; the market potential they offer is not large enough to consume the predicted production of petroleum-derived alpha olefins and alcohols.

A key to the solution lies in the answer to the question of whether or not alpha olefins can be used in making biologically soft detergents without first being converted to straight-chain alcohols. According to R. I. Stirton's report to the Soap and Detergent Association Convention in January 1962, if conversion is unnecessary, alpha olefins priced at 8 to 14 cents per pound are likely to gain a large share of the present ABS detergent market. 12/ If they must first be converted to alcohols, natural fatty alcohols that can be produced for a cost of about 5 cents per pound above the cost of raw materials can offer strong competition to alpha olefins at the price mentioned.

Four big "if's" exist in the market picture for petroleum-derived alpha olefins and straight-chain alcohols derived from them. First, to open the commercial processing plants necessary to manufacture at low cost, producers must anticipate that the product will have immediate large-scale use. Trade information sources say that the present "open" market for alcohols from olefins is too small to warrant large-scale production. Second, in the very cost-conscious detergent industry it costs more to produce straight-chain alkylbenzenes with the new synthetic alpha olefins than it does to make branched-chain alkylbenzenes from propylene. Third, it will be necessary to prove that, when produced on a large scale, products made from synthetic fatty alcohols or alpha olefins are acceptable replacements for existing natural fatty products. Fourth, if petrochemicals begin to displace fats at current prices, fat prices will decrease because other markets will not quickly absorb the supply not used in detergents and soap. Although tallow and grease now used in surfactants cost less than 6 cents per pound and may drop 1 or 2 cents more, the effect of price competition on petrochemicals may reduce profits sufficiently to cause production of replacements for natural materials to be undesirable. These four "if's" make the venture into the production of synthetic alpha olefins and synthetic fatty alcohols as replacements for fats and oils a "market" gamble.

12/ Stirton, R. I. Alpha Olefins and Some of Their Derivatives. (Abstracted in Oil, Paint & Drug Rptr., Jan. 29, 1962).

FUTURE HOUSEHOLD DETERGENTS

According to detergent trade sources, biologically soft synthetic detergents will be available for consumption late in 1964. On the basis of the economic and technical evaluation of detergents and surfactants given in this report, the following generalizations can be made about the future market opportunity of detergents made from fats and oils.

1. Greater use of fats and oils in laundry soap does not appear likely. Synthetic detergents have properties housewives find necessary for the performance of many cleaning tasks. Their ability to clean hard surfaces is a good example.

2. Detergent makers expect to be able to use petroleum raw materials in the manufacture of soft detergents. These new raw materials are almost in a position to compete in price with raw materials needed in detergents of the old ABS type. Although prices to detergent makers and to consumers have not been generally announced, developer firms have indicated that petroleum raw materials will cost only slightly more, if any, than presently used ABS materials.

3. The availability of low-cost soft detergents made from petroleum, if technically competent from the standpoint of cleansing power and degradability, will not encourage wide-scale use of fats and oils in synthetic detergents. In 1947, the year in which the volume of fats used for soapmaking was highest, 2 1/4 billion pounds were used. Today, supplies of inedible fats are not available to meet total detergent production needs. Most of the more than 4 billion pounds of inedible tallow and grease available annually are used in products providing higher returns to renderers than the residual fats (approximately 700 million pounds) that go into soaps. With low-cost soft detergents in view, producers do not regard conversion of greatly increased volumes of tallow and grease into synthetic detergents as economically feasible unless some newly discovered fat-based product discovery proved to be highly efficient in cleansing power or some other function. Large investment, large-volume processing plants, as well as low-cost (under 5 cents a pound) tallow supplies in large volumes, would be needed to make current types of fat-based surfactant products competitive with petroleum-derived products.

Thus, the prospects do not appear favorable for upgrading the position of fats in soap and detergent making, at present the lowest priced outlet for renderers' fats. Changes in the detergent industry's use of fats and oils resulting from present water pollution problems are not expected to affect greatly the marketing of these materials.

Water pollution problems will not be solved completely by a change in detergent formulations. However, detergent foam in sewage effluent and water supplies can be eliminated if more degradable detergents are used. If degradable detergents are not used, methods for the complete oxidation of detergents will be needed.

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